

Freshwater Tardigrades from Korea

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韓國 淡水産 緩步類

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적 요

1986년 5월부터 1988년 1월까지 전국 19개 지점의 강, 호수, 연못, 웅덩이, 논등의 담수역에서 채집된 완보류를 동정한 결과 2과 7종을 확인 하였는데 이중, *Dactylobiotus dispar*와 *Hypsibius dujardini*를 제외한 나머지 5종은 한국에서 처음으로 보고되는 종들로, 이들은 다음과 같다: *Macrobiotus hufellandi*, *M. richtersi*, *Hypsibius convergens*, *Isohypsibius granulifer*, *Pseudobiotus megalonix*. 한국미기록 5종을 모두 기재, 논의하였고 아울러 도판을 작성하였다.

Key words: taxonomy, freshwater tardigrades, Korea.

INTRODUCTION

A division of Tardigrada into hydrophilous, hygrophilous, xerophilous, and euryhygrous species has been attempted. Of the four types, the majority of Tardigrada are euryhygrous species, which occur in all conditions of humidity. Hygrophilous species are characterized by the semiaquatic species which occur in aquatic and semiaquatic situations such as moist moss. Hydrophilous species live only in permanent freshwater habitats. However, there are some species which occur occasionally in the typical freshwater habitats of the euryhygrous species. Therefore, it is often very difficult to delimitate the freshwater species because some species occur both in terrestrial mosses and freshwater habitats. In this paper we dealt with mostly the aquatic species but also included semiaquatic and the euryhygrous species found in freshwater habitats.

About 50 species of Tardigrada found in freshwater are known to the world. They are not planktonic but bottom dwellers on the surface or in the interstitial spaces of the sediment, and also are found from floating leaves on small ponds, or wet forest litters at the freshwater situations. On the freshwater fauna of Korea, Moon and Kim (1988) have referred three freshwater species in the paper of Eutardigrada from Korea. Since that report, there has been no work on the fauna of freshwater species of this country.

For the taxonomic study on the Korean freshwater tardigrades samplings from different sites in South Korea were conducted (Fig. 1). As the result, seven species of 2 families were identified, of which five species are newly known to Korea.

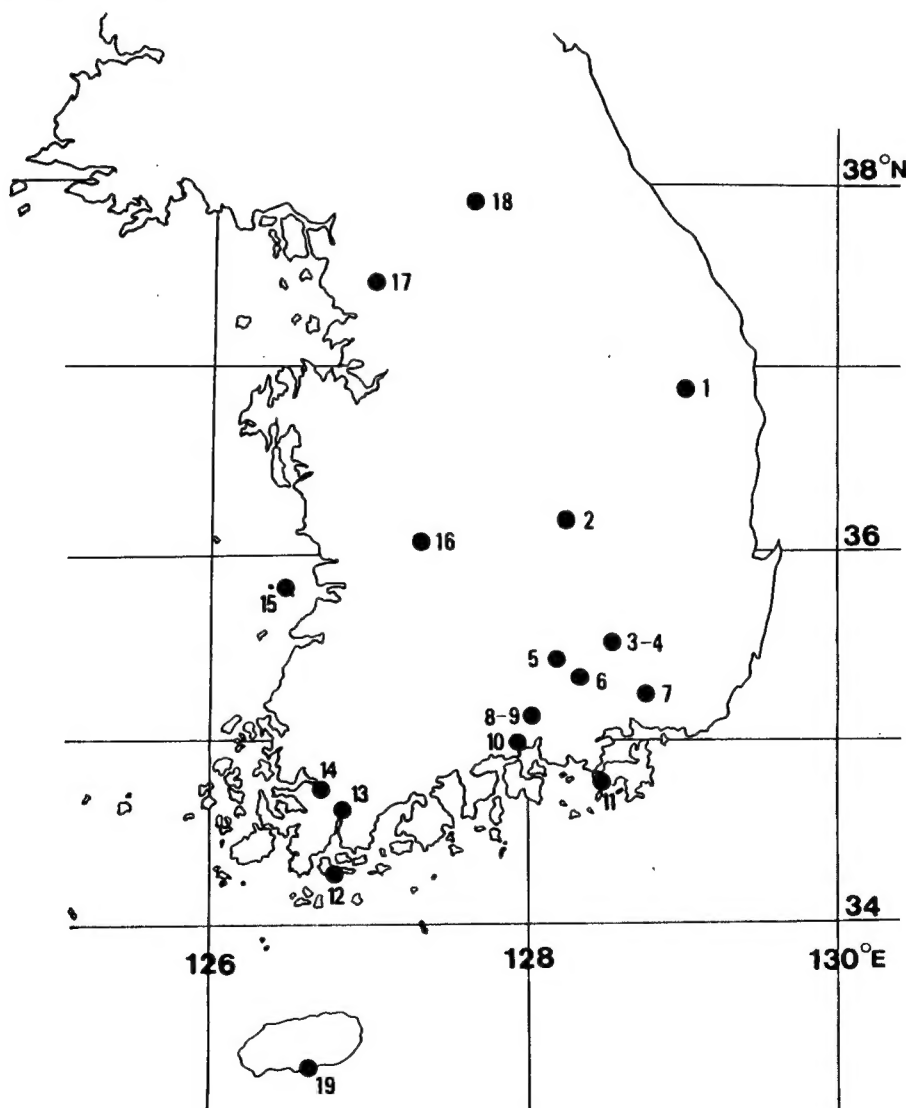


Fig. 1. A map showing the collection sites. 1, Ch'ungyang; 2, Sewöl reservoir (Kumi); 3, Up'o; 4, Mokp'o; 5, Hapch'ön; 6, Nam River (Pöpsu-myön); 7, Chunamji; 8, Chilnal; 9, Oesong; 10, Songwön reservoir (Chin'gyo-myön); 11, Ch'ungmu; 12, Wando-gun; 13, Kangjin; 14, Wölch'ul Mt. (Yöngam); 15, Sönyu I.; 16, Taedun Mt.; 17, Kwanak Mt.; 18, Kangwön Nat'l Univ.; 19, Sögwip'o.

MATERIALS AND METHODS

Specimens were collected during the period from May, 1986 to January, 1988 from the freshwater habitats such as rivers, lakes, ponds, rice fields, and streams. Collections were made with a conical plankton net (25 μ m and 100 μ m in pore diameter) in rivers and lakes, and a small hand net (48 μ m in pore diameter) or a pipet in small ponds, rice fields, and streams. Samples were fixed with 4% neutral formalin, and preserved in 70% ethanol if necessary. After sorted at X50 magnification by using a micropipet, samples were transferred to Tween 80 and vibrated on vortex to wash the debris on the surface of the animal. The specimens were mounted on microscopic slides, and then the coverslips were sealed. The mounting medium was "Liquido di Faure" (Ramazzotti, 1972) or Hoyer's type medium. Examination and drawings were conducted at up to X1000 magnification of light or phase-contrast microscope. The scheme of classification in this paper is in accordance with that given by Ramazzotti (1983).

SYSTEMATIC ACCOUNT

Phylum Tardigrada

Class Eutardigrada Marcus, 1927

Order Parachela Schuster, Nelson, Grigarick and Christenberry, 1980

Family Macrobiotidae Thulin, 1928

Genus *Dactylobiotus* Schuster, Nelson, Grigarick and Christenberry, 1980

1. *Dactylobiotus dispar* (Murray, 1907)

Macrobiotus dispar Murray, 1907a (pp.6-10, figs.1-5); Murray, 1907b (p.662, pl.II, figs. 11a-11g); Murray, 1907c (p.676); Murray, 1907d (pp.850-851); Marcus, 1929 (pp.435-436, fig.272); Marcus, 1936 (pp.187-189, fig.186); Morgan & King, 1976 (p.77, fig.47); Morgan, 1976 (pp.612-613, figs.E-G); Ramazzotti, 1972 (pp.546-548, fig.342).

Macrobiotus macronyx: Cuénot, 1932 (pp.69-70, figs.63-65).

Dactylobiotus dispar: Ramazzotti, 1983 (pp.252-253, fig.93).

Material examined: 1 ind., Sögwip'o, Feb. 11, 1987 (C.Y.Chang); 21 inds., Taedun Mt., Jan., 1987 (C.Y.Chang); 3 inds., Wando-gun, Feb. 8, 1987 (C.Y.Chang); 19 inds., Tokap reservoir, Feb. 7, 1987 (C.Y.Chang); 2 inds., Hapch'ön, May 7, 1988 (C.Y.Chang); 8 inds., Songwön reservoir, Jan. 20, 1987 (C.Y.Chang); 11 inds., Pöpsu-myön, Jan. 17, 1987 (C.Y. Chang).

Genus *Macrobiotus* Schultze, 1834

2. *Macrobiotus hufellandi* Schultze, 1834

(Fig. 2)

Macrobiotus hufellandii Schultze, 1834 (pp.5-7, figs.1-4); Murray, 1907e (p.522); Marcus, 1928 (pp.145-147, fig.7); Marcus, 1929 (pp.439-442, fig.276); Marcus, 1930 (pp.375-376, fig.5); Marcus, 1936 (pp.194-198, fig.192); Petersen, 1951 (pp.65-67, fig.23); Schuster & Grigarick, 1970 (p.192, figs.5,6); Argue, 1971 (p.407, figs.11,12); Beasley, 1972 (p.25, fig.7); Morgan & King, 1976 (p.84, fig.53); Beasley, 1978 (p.135, fig.12); Ramazzotti, 1972 (pp.563-565, fig.358).

Macrobiotus Hufellandi: Cuénot, 1932 (pp.56-58, figs.41-43).

Macrobiotus hufellandi: Bertolani, 1982 (pp.40-42, fig.23); Ramazzotti, 1983 (pp.751-753, fig.487).

Material examined: 1 ind., Sewöl reservoir, Apr. 20, 1986 (S.M.Yoon); 2 inds., Hapch'ön, May 7, 1988 (C.Y.Chang).

Description: Body length about 300-400 μ m. Cuticle smooth and transparent. Body colorless though opaque, light brown pigmented in older individuals. Eyespots present. Buccal aperture with 10 well developed peribuccal lamellae. Three transverse crescents present on armature of buccal tube posteriorly. Over transverse

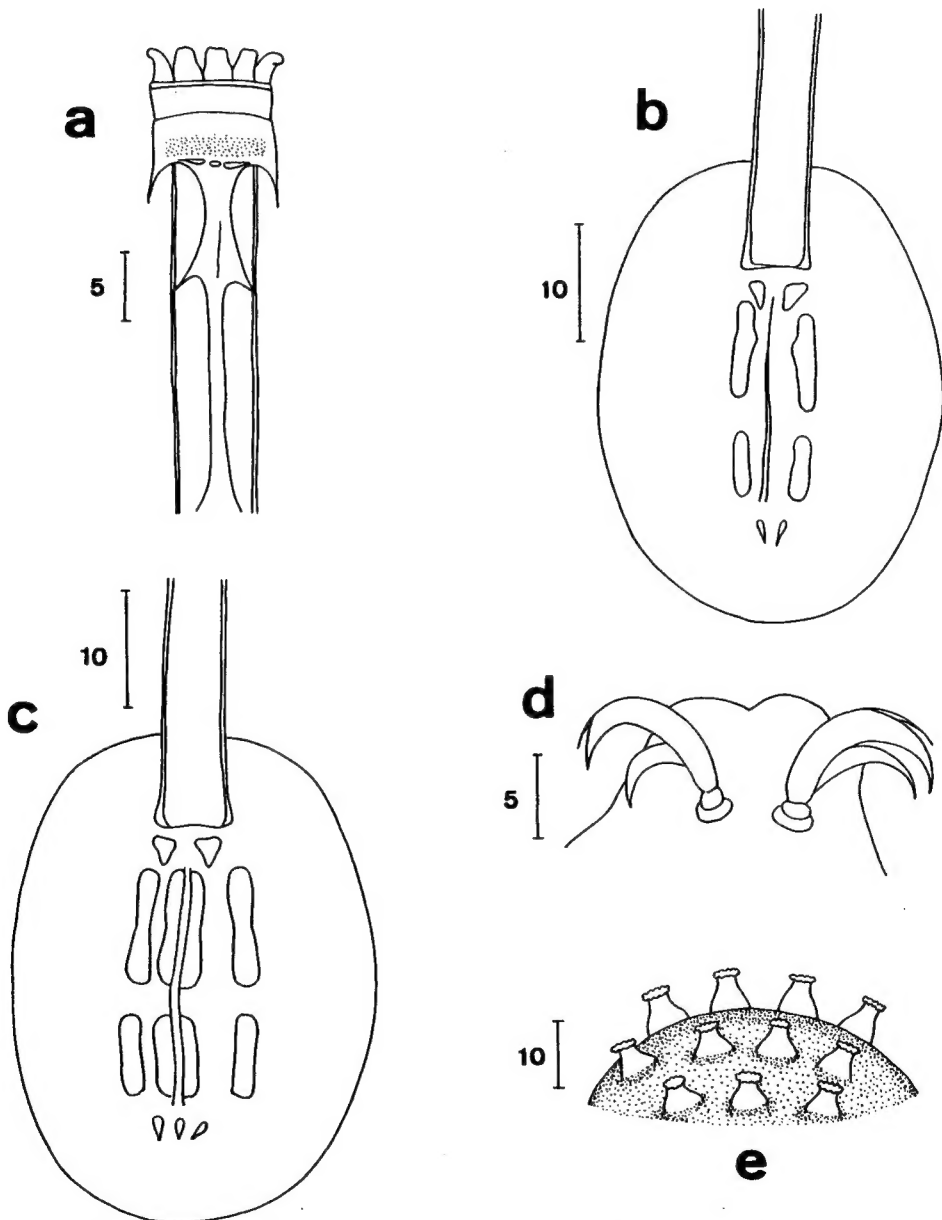


Fig. 2. *Macrobiotus hufellandi* Schultze, 1834. a, buccal apparatus; b & c, pharyngeal bulbs; d, claws of the fourth pair of legs; e, part of egg. (Scales in μ m)

crests, band consisting of fine granules present (Fig. 2a). Buccal tube about 5-6 μ m wide (outside). Length of buccal tube from mouth (except peribuccal lamellae) to point of entry to pharynx about 34-38 μ m. Pharyngeal bulb round or slightly oval, containing well developed apophyses and two rod-like macroplacoids; first macroplacoid longer than second macroplacoid and constricted or slightly protruded at about midpoint, but not reaching up to double length of second. Microplacoid present and somewhat long (Fig. 2b, 2c). Doubleclaws of *hufellandi* type, Y shaped, comparatively small (Fig. 2d). Lunules present and particularly small on first three pairs of legs, but larger and more rugged on fourth pair of legs. Each principal arm of doubleclaws bearing two accessory points.

Eggs about 75 μ m in diameter including processes. Processes of eggs shaped like egg-cup turned upside down with its terminal disc dentated (Fig. 2e).

Remarks: The size of this species was reported up to 1200 μ m long, but our specimens were 300-400 μ m. Some variations of macroplacoids were reported. According to Petersen (1951), first macroplacoid may be clearly divided, and so considered as two independent placoids placed very close together. However, in our specimens, the constriction at nearly midpoint of the first macroplacoid was not so strong, but rather slight. It has been reported that in some cases, juveniles had two macroplacoids of equal length while older individuals often possessed three macroplacoids, of which the third macroplacoid was generally longest (Morgan & King, 1976). Buccal tube was also reported to be variable in its width (3-7 μ m). *M. hufellandi* was reported to be widely distributed, and to be occurred in soil, humus, moss, lichen, and water. Many individuals were found in terrestrial moss, however, no morphological differences were noted when compared with the individuals collected at freshwater habitats. Only those found in freshwater habitats were remarked in the material examined section.

3. *Macrobiotus richtersi* Murray, 1911

(Fig. 3)

Macrobiotus richtersi Murray, 1911 (p.7); Murray, 1913 (p.142); Marcus, 1928 (pp.122-123, fig.143); Marcus, 1929 (pp.408-410, fig.249); Marcus, 1930 (pp.372-374, fig.2,3); Marcus, 1936 (p.157, fig.166); Petersen, 1951 (pp.70-72, fig.26).

Macrobiotus richtersi: Argue, 1971 (p.408, figs.17, 18); Schuster, 1971 (p.217, figs.11-13); Morgan, 1976 (pp.615-617, fig.2,P-S); Morgan & King, 1976 (p.92, fig.60); Ramazzotti, 1972 (pp.595-596, fig.390); Bertolani, 1982 (pp.42-44, fig.24); Ramazzotti, 1983 (pp.799-801, fig.532).

Material examined: 2 inds., a reservoir in Ch'ungmu, Aug. 20, 1987 (C.Y.Chang); 1 ind., Wölch'ul Mt., Jul. 28, 1988 (C.Y.Chang).

Description: Body length about 300 μ m. Cuticle smooth and transparent. Body colorless, or brown pigmented in older individual. Eyespots present. Buccal aperture with 10 well developed peribuccal lamellae. Armature of buccal tube beneath peribuccal lamellae bearing band consisting of many granules anteriorly; delicate row of denticles posteriorly, which appearing as comb; three transverse crescents under row of denticles. Median crescent shorter than left or right crescent (Fig. 3a). Buccal tube wide, somewhat variable in length (7.5-9 μ m, outside) among almost same size of animals. Length of buccal tube from mouth (except peribuccal lamellae) to point of entry to pharynx about 44-48 μ m. Pharyngeal bulb round, or somewhat oval, containing prominent apophyses and three rod-like macroplacoids; first and second macroplacoid nearly equal in length but third slightly longer; third macroplacoid may have constriction at terminal portion. Microplacoid somewhat long, arranged more or less parallel to each other, and well developed. Doubleclaws of *hufellandi* type, Y shaped, comparatively small with lunule at base (Fig. 3b). Each principal arm of doubleclaws with two accessory points.

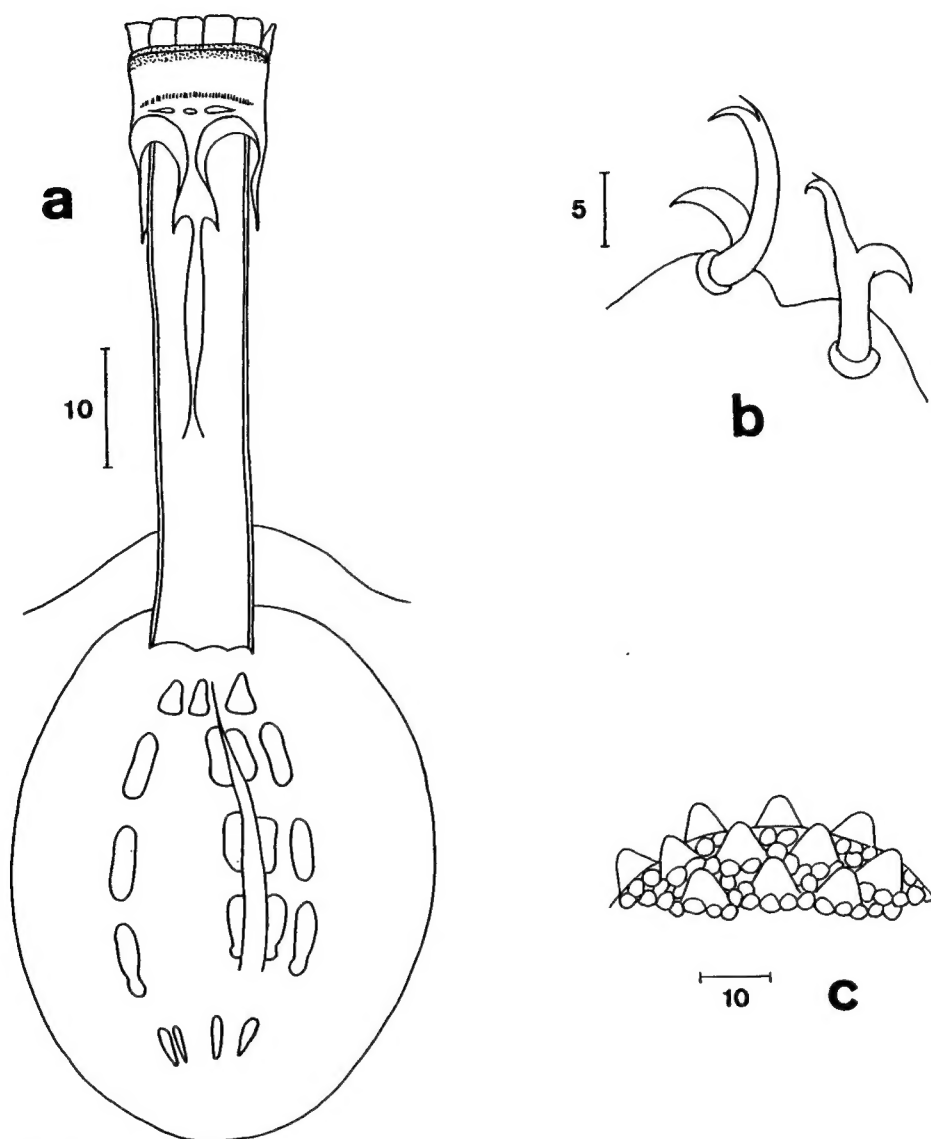


Fig. 3. *Macrobiotus richtersi* Murray, 1911. a, buccal apparatus; b, claws of the fourth pair of legs; c, part of egg. (Scales in μm)

Eggs about $65\mu\text{m}$ in diameter, laid freely; covered with truncated cone-shaped processes between which shell divided into small round or roughly polygonal areas (Fig. 3c).

Remarks: Many variations were reported in *M. richtersi*, especially in the width of buccal tube, the shape of macroplacoids and microplacoid, and the presence or absence of eyes. Therefore, this species has been often confused with *M. hamsworthi* and *M. areolatus*. Petersen (1951) reported two types of *M. richtersi* which were different in the shape of buccal apparatus, claws, and even somewhat different in the shape of egg processes, although the egg is considered as one of the most reliable characters to distinguish this species from others. Our specimens, however, were in most accordance with the description of Bertolani (1982). *M. richtersi* is widely distributed, and recorded to be found not only in terrestrial moss but occa-

sionally in aquatic situations. On the other hand, Schuster (1971) reported that this species was apparently restricted to moist habitats. Our specimens were collected from a reservoir, and mixed samples of moss and lichen which were always in wet condition near stream.

Family Hypsibidae Pilato, 1969

Genus *Hypsibius* Thulin, 1928

4. *Hypsibius convergens* (Urbanowicz, 1925)

(Fig. 4)

Macrobiotus convergens Urbanowicz, 1925 (pp.136-139).

Hypsibius (Hypsibius) convergens: Marcus, 1929 (pp.501-502, fig. 339); Marcus, 1936 (pp.266-269, fig.257); Argue, 1971 (p.409, fig.21), Ramazzotti, 1972 (pp.455-456, fig.242); Beasley, 1978 (p.136, figs.16, 17).

Hypsibius convergens: Marcus, 1928 (pp.205-206, fig.252); Petersen, 1951 (pp.73-74, fig.28); Schuster & Grigarick, 1970 (p.193, figs.12,13); Schuster, 1971 (p.222, figs.27-29); Bertolani, 1982 (pp.86-88, fig.48); Ramazzotti, 1983 (pp.549-550, fig.327).

Material examined: 2 inds., a pond in Sögwip'o, Apr. 23, 1987 (C.Y.Chang).

Description: Body length about 380-400 μ m. Cuticle smooth and transparent. Body colorless. Eyespots present. Buccal tube about 6.5 μ m wide (outside) and 44 μ m long from mouth to point of entry to pharynx. Pharyngeal bulb round or slightly oval, containing normally developed apophyses and two rod-like macroplacoids; first macroplacoid with slight constriction at midpoint longer than second macroplacoid; first about 8 μ m and second 5 μ m long. Microplacoid absent (Fig. 4b). Doubleclaws with principal arm bearing one accessory point diverse, somewhat large, especially often much curved at its terminal portion. Principal arm of outer doubleclaws usually more elongated and thinner than secondary arm. Outer doubleclaws usually stalked and larger than inner doubleclaws (Fig. 4c, 4d). Claws of fourth pair of legs slightly larger than those of other three pairs of legs. Lunules at base of doubleclaws absent.

Remarks: *H. convergens* resembles *H. dujardini* very much. According to Petersen (1951) and Schuster & Grigarick (1970), *H. convergens* is easily distinguished from *H. dujardini* by its shorter, thicker macroplacoids and the absence of microplacoid. However, our specimens without microplacoid had longer macroplacoids than those of *H. dujardini* in about same size of individuals of the two species, which was in much accordance with the description of Bertolani (1982). The length of buccal tubes was longer in our specimens than those described by Argue (1971), who remarked that it was slightly less than 2 μ m. Therefore, we consider that the length of placoids is not reliable character to distinguish these two species, and there is also some variation in the width of buccal tube as the case of some other species. Besides the larger eyespots and presence of microplacoid of *H. convergens*, it is necessary to find more reliable characters to distinguish this species from *H. dujardini*.

5. *Hypsibius dujardini* (Doyère, 1840)

Macrobiotus Dujardin Doyère, 1840 (pp.287-288).

Macrobiotus islandicus: Murray, 1905 (p.690, pl.III, figs. 12a-12c).

Hypsibius Dujardini: Cuénot, 1932 (pp.73-74).

Hypsibius (Hypsibius) dujardini: Marcus, 1936 (pp.263-266, fig.256); Ramazzotti, 1972 (pp.456-458, fig.243); Argue, 1974 (pp.919-921, figs.5-8); Morgan & King, 1976 (pp.104-105, fig.70).

Hypsibius dujardini: Marcus, 1928 (pp.202-204, fig.249); Marcus, 1929 (pp.497-500, fig.337); Petersen, 1951

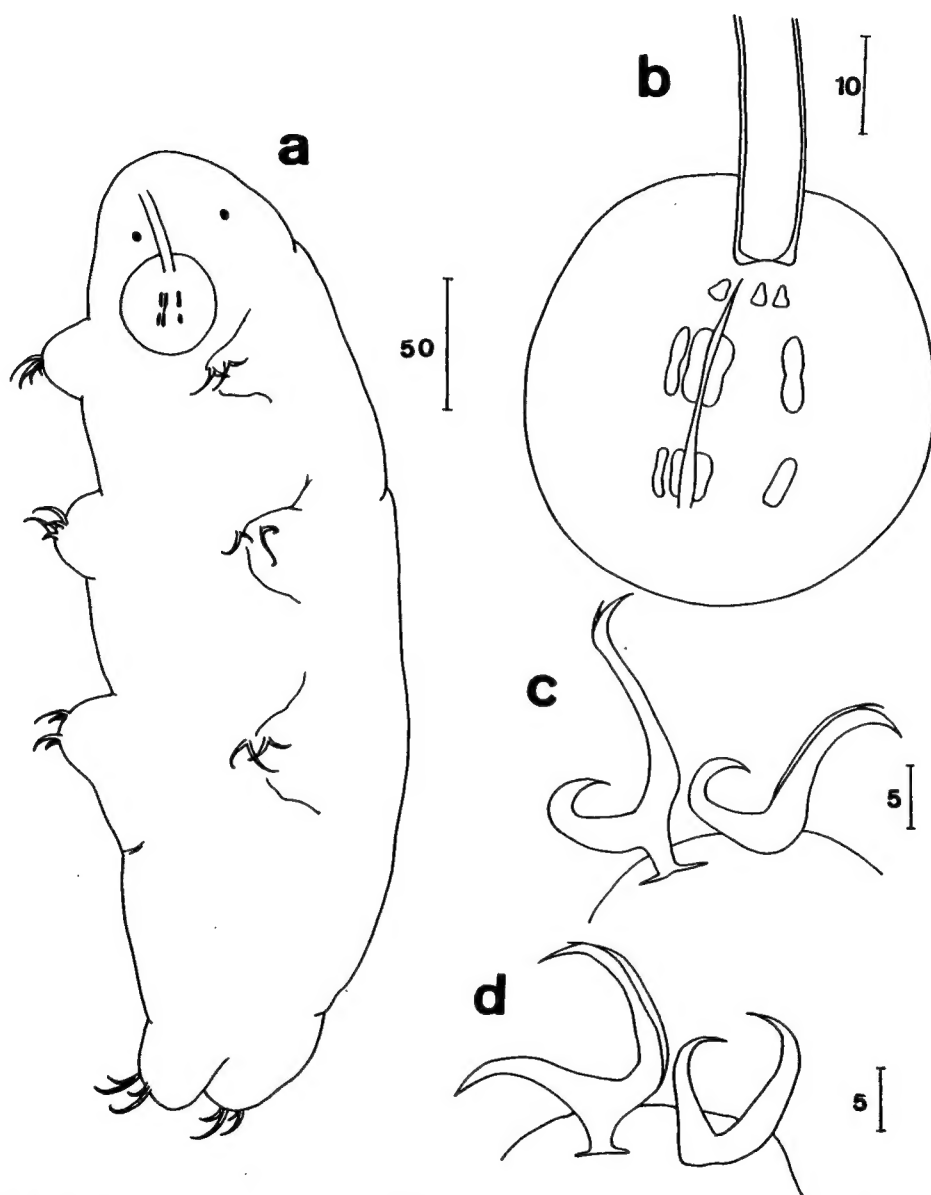


Fig. 4. *Hysibius convergens* (Urbanowicz, 1925). a, whole animal; b, pharyngeal bulb; c, claws of the second pair of legs; d, claws of the third pair of legs. (Scales in μm)

(pp.72-73, fig.27); Schuster *et al.*, 1977 (p.124, fig.9, 10); Bertolani, 1982 (p.86, fig.47); Ramazzotti, 1983 (pp.550-551, fig.328).

Material examined: 3 inds., Kwanak Mt., Apr. 12, 1987 (M.K.Shin).

Genus *Isohypsibius* Thulin, 1928

6. *Isohypsibius granulifer* Thulin, 1928

(Fig. 5)

Isohypsibius granulifer Thulin, 1928 (pp.240, 252, fig.23); Bertolani, 1982 (p.63, fig.33); Ramazzotti, 1983 (pp.619-620,

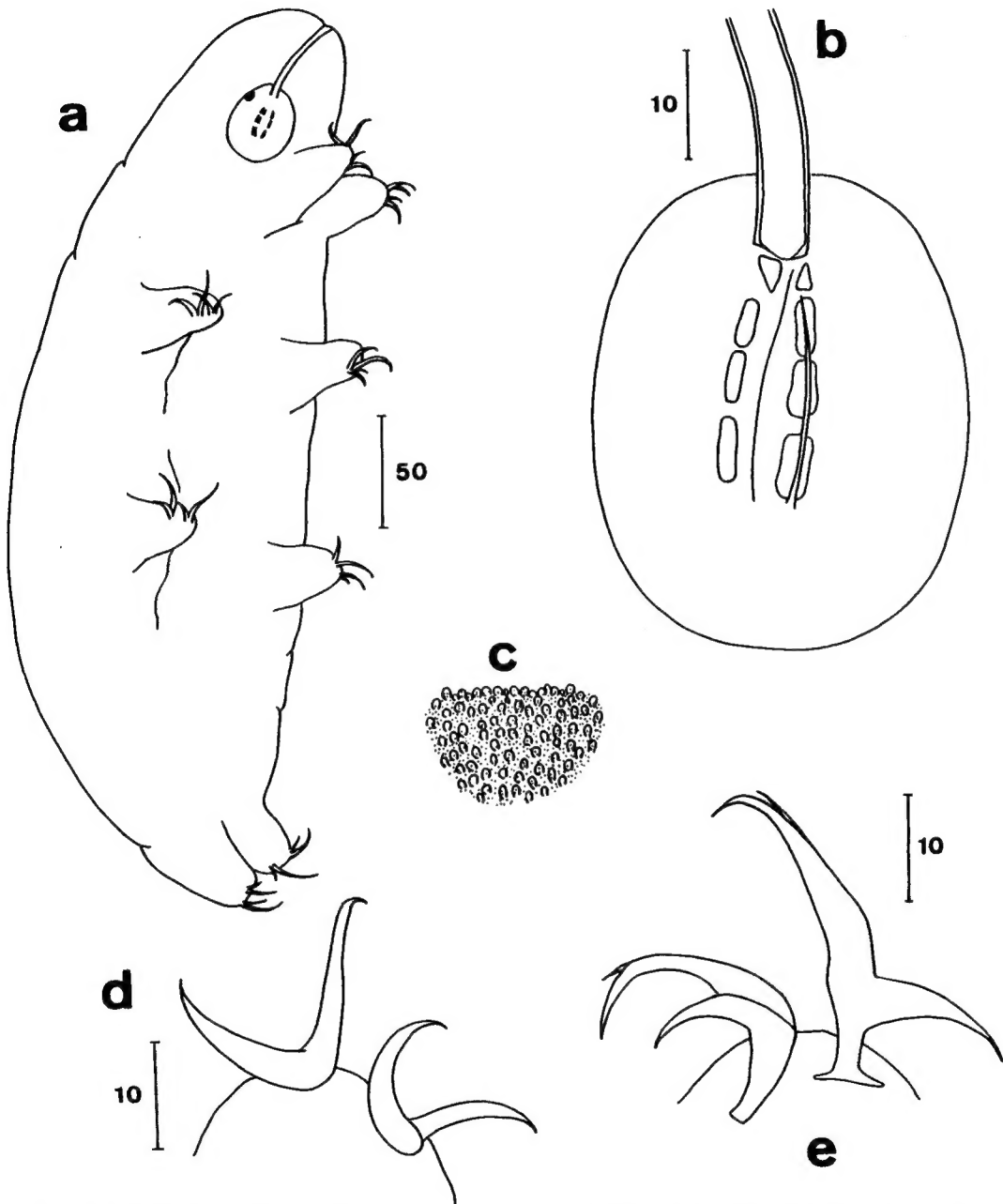


Fig. 5. *Isohypsibius granulifer* Thulin, 1928. a, whole animal; b, pharyngeal bulb; c, surface pattern of cuticle; d, claws of the first pair of legs; e, claws of the fourth pair of legs. (Scales in μm)

fig.330).

Hypsibius (Isohypsibius) granulifer: Marcus, 1929 (pp.488-489, fig.330); Marcus, 1936 (pp.254-256, fig.251); Ramazzotti, 1972 (pp.494-495, fig.282).

Hypsibius granulifer: Cuénot, 1932 (p.86, fig.92).

Material examined: 7 inds., a pond in Kangwŏn Nat'l Univ., Feb. 10, 1988 (C.B.Kim).

Description: Body length about 250-360 μ m. Body colorless, and densely, regularly covered with small tubercles (Fig. 5c). Tubercles on dorsal and lateral part of body larger than those on legs and ventral part. Eyespots large, usually placed more posteriorly, nearly at place of anterior part or dorsally anterior limit of pharyngeal bulb (Fig. 5a). Buccal tube about 4-5 μ m wide (outside) and 34-35 μ m long from mouth to point of entry to pharynx. Pharyngeal bulb oval, containing normally developed apophyses and three rod-like macroplacoids; first and second macroplacoid equal in length, closer together than second macroplacoid to third one; third macroplacoid longer than first two macroplacoids (Fig. 5b). Doubleclaws with principal arm bearing one accessory point comparatively large, elongated, and similar on each legs. Claws of each leg often stalked; stalks of outer claws generally longer than those of inner claws. Claws of fourth pair of legs slightly larger than those of other three pairs of legs (Fig. 5e). Legs slender. Lunules at base of inner doubleclaws present at first three pairs of legs.

Genus *Pseudobiotus* Schuster, Grigarick, Nelson and Christenberry, 1980

7. *Pseudobiotus megalonix* (Thulin, 1928)

(Fig. 6)

Isohypsibius megalonix Thulin, 1928 (p.240)

Hypsibius augusti: Marcus, 1928 (pp.194-195, fig.239); Marcus, 1929 (pp.492-494, fig.333).

Hypsibius dujardini: Marcus, 1928 (pp.202-204, fig.249).

Hypsibius (Isohypsibius) megalonix: Marcus, 1929 (pp.489-491, fig.331); Marcus, 1930 (pp. 377-378, fig.6).

Hypsibius megalonix: Cuénot, 1932 (pp.85-86, figs.90-91).

Hypsibius (Isohypsibius) augusti: Marcus, 1936 (pp.256-259, fig.252); Ramazzotti, 1972 (pp.480-481, fig.267); Morgan & King, 1976 (p.100, fig.66).

Pseudobiotus megalonix: Bertolani, 1982 (pp.49-51, fig.26); Ramazzotti, 1983 (pp.901-903, fig.611).

Material examined: 2 inds., Ch'ungyang, May 5, 1987 (C.Y.Chang); 48 inds., Sönyu I., May 6, 1986 (C.Y.Chang); 2 inds., Up'o, Jan. 21, 1988 (C.Y.Chang, K.S.Min, M.O.Song); 7 inds., Up'o, Feb. 23, 1988 (K.S.Min, M.O.Song); 2 inds., Up'o, Jun. 26, 1988 (C.Y.Chang, K.S.Min, M.O.Song); 2 inds., Mokp'o, Feb. 23, 1988 (C.Y.Chang, K.S.Min, M.O.Song); 9 inds Mokp'o, Apr. 16, 1988 (C.Y.Chang, K.S.Min, M.O.Song); 7 inds., Oesong, Feb. 22, 1988 (C.Y.Chang, K.S.Min, M.O.Song); 2 inds., Chunamji, Jan. 14, 1989 (M.O.Song); 6 inds., Chilnal, Jan. 20, 1988 (C.Y.Chang, M.K.Shin); 6 inds., Nam River, Pöpsu-myön, Jan. 17, 1987 (C.Y.Chang, M.K.Shin); 1 inds., Kangwön Nat'l Univ., Feb. 10, 1988 (C.B.Kim); 2 inds., Kangjin, Feb. 10, 1987 (C.Y.Chang); 7 inds., Songwön reservoir, Jan. 20, 1987 (C.Y.Chang); 2 inds., Tongp'angemot, Jan. 14, 1989 (M.O.Song).

Description: Body length about 300-450 μ m. Cuticle smooth and transparent. Body colorless or light brown. Eyespots present. Buccal aperture with many small peribuccal lamellae. Armature of anterior part of buccal tube bearing band consisting of granules posteriorly; three transverse crescents under band of granules dorsally and ventrally. Median crescent shorter than left or right crescent (Fig. 6e). Width of buccal tube narrow (5-7 μ m, outside), but variable up to 9 μ m. Anterior part of buccal tube puffed, and at posterior end of puffing buccal tube slightly narrower (up to 1 μ m) than any other parts of tube (Fig. 6d). Pharyngeal bulb round, slightly oval, or oval containing normally developed apophyses, and two long, slender macroplacoids; first macroplacoid shorter than second macroplacoid, which very close together, often appearing to contact each other (Fig. 6c). Microplacoid absent. Doubleclaws of *Hypsibius* type, very long and dissimilar among legs. Principal arm without accessory point. Lunules at base of doubleclaws absent.

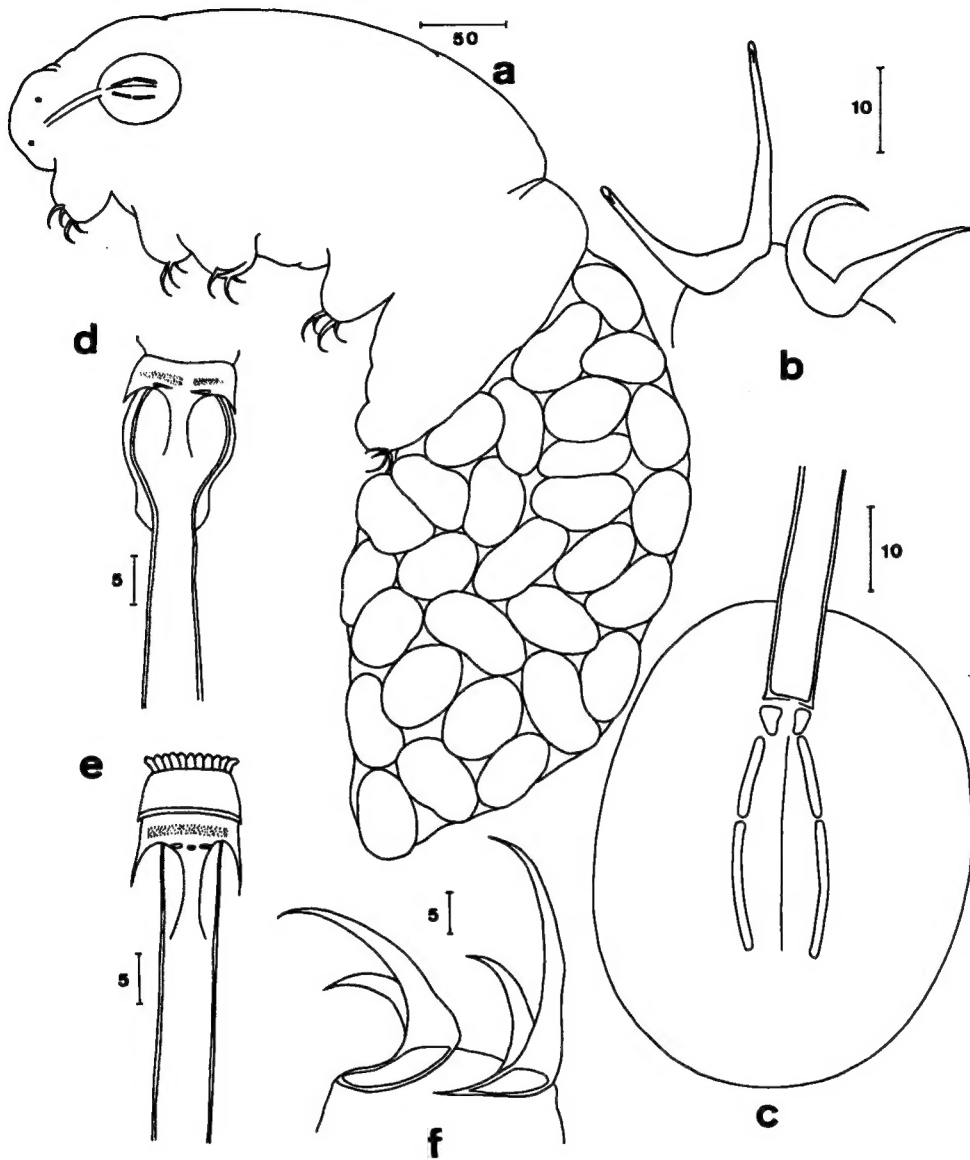


Fig. 6. *Pseudobiotus megalonix* (Thulin, 1928). a, whole animal; b, claws of the second pair of legs; c, pharyngeal bulb; d, lateral view of buccal apparatus; e, ventral view of buccal apparatus; f, claws of the fourth pair of legs. (Scales in μm)

Eggs round, smooth, deposited in molted cuticle, which containing about 20-50 eggs (Fig. 6a).

ABSTRACT

Tardigrades were collected in freshwater habitats, such as rivers, streams, lakes, ponds and rice paddies at 19 different localities in Korea, during the period of May 1986-January

1988, and seven species were identified: *Dactylobiotus dispar*, *Macrobiotus hufellandi*, *M. richtersi*, *Hypsibius convergens*, *H. dujardini*, *Isohypsibius granulifer*, and *Pseudobiotus megalonix*. Five species of these except *D. dispar* and *H. dujardini*, are new to Korea, which are fully described and illustrated.

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